11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25
ICAM 2009

Ionic Polymer-Metal Composite Material as a Diaphragm for Micropump Devices

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Abstract – Ionic polymer–metal composite (IPMC) is a new functional material that being flexible and capable of operating in liquid environments is a new applicant for diaphragm in micropumps. Two IPMC diaphragms have been fabricated (Fig. 1) and tested. Diaphragm Nº. 1 showed the largest bending deformation (~0.17mm) under ~13.3mA (Fig. 2a), generating a maximum stroke volume of about 80μl (Fig. 2b). IPMC diaphragm Nº. 2 showed maximum bending deformation of about 0.13mm under ~26mA (Fig. 3), generating a maximum stroke volume of 8.9μl. Figure 4 shows the experimental set-up made by two acrylic plates and one Teflon isolating the micropump mechanism.

The IPMC is a new promising functional material for diaphragms in micropumps. Previously, piezoelectrically actuated diaphragms **[1]** produced high actuation forces and fast mechanical responses, but requiring high input voltages. Thermopneumatically diaphragms **[2]** instead need low input voltages and can be very compact, but show long thermal time constants. Electrostatically actuated diaphragms **[3]** have fast response times and low power consumption, but high input voltages. On the other hand, the IPMC material requires very low voltages and power consumption [4], also being flexible and operating in liquid and air.

Two IPMC diaphragms have been fabricated (Fig.1). To analyze their displacement and stroke volume, the experimental assembly shown in Fig. 4 has been used. Two acrylic plates and two copper rings were constructed (Fig. 4a). The IPMC diaphragms are put in the middle of the two rings like a sandwich, using the two acrylic plates for support (Fig. 4b). Figures 2a show the displacement and Fig. 2b the stroke volume of the IPMC diaphragm Nº. 1. The diaphragm reached a maximum displacement of 0.17 mm with a corresponding stroke volume of 50.49 μl for 13.30 mA. Figure 3 shows the results for diaphragm Nº. 2. The diaphragm displacement was measured in several positions to obtain a graphical representation of its deflection. This process allowed us to determinate its maximum stroke volume. Using this representation of the piece, see Fig. 3b, it was possible to determinate the volume as being about 8.29 μl.

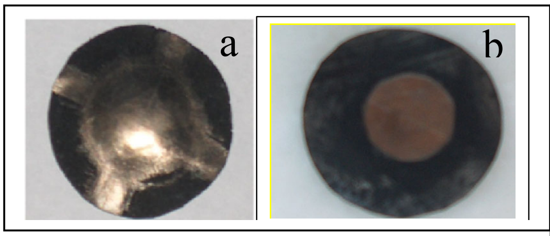

Figure 1: (a) IPMC diaphragm Nº. 1, (b) and Nº. 2

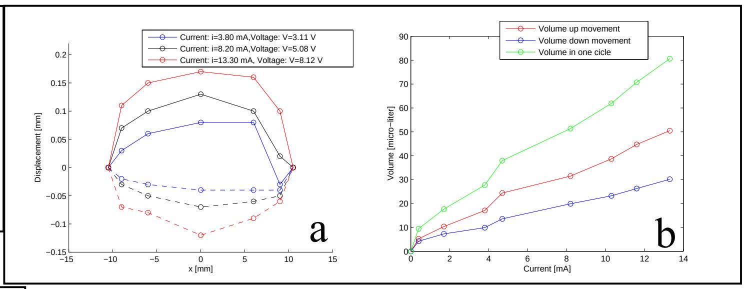

Figure 2: Diaphragm Nº.1 (a) displacement and (b) stroke volume.

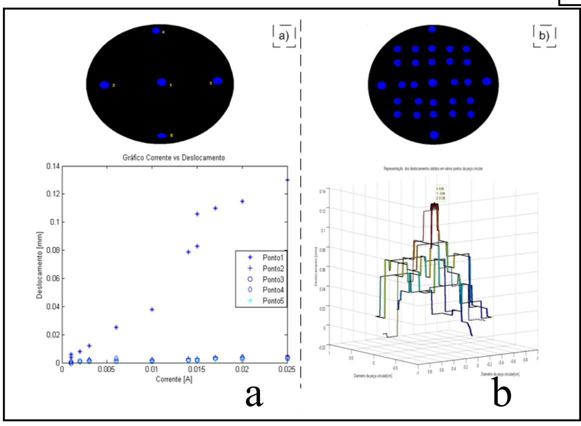

Figure 3: Diaphragm Nº.2 (a) central and borders displacement, (b) view of diaphragm volume.

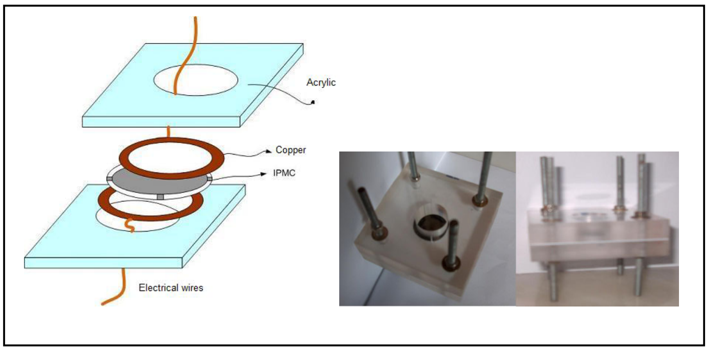

Figure 4: (a) Experimental assembly and (b) micropump prototype.

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